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Content Analysis of Communication in a Hierarchical Navy Team

LISA B. ACHILLE

Navy Center for Applied Research in Artificial Intelligence
Information Technology Division

KAY G. SCHULZE

Computer Science Department
United States Naval Academy
Annapolis, MD

and

Navy Center for Applied Research in Artificial Intelligence
Information Technology Division

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INTRODUCTION

The AEGIS Combat Information Center (CIC) of naval ships is a complex, distributed system composed of multiple computers with significant amounts of human computer interaction and multiple, verbal-communication networks with a very high degree of human-to-human communication. This complexity is increased since the major command communication network is shared by team members, each of whom is competing for access.

The command net is the primary vehicle for team coordination and decision making. The CIC team (approximately 22 members) has a hierarchical chain of command based on individual responsibilities. The team members who communicate over the command net are largely at the top and middle levels of the hierarchy. The tactical action officer (TAO) is the primary decision maker, superseded only by the captain. The TAO bases his decisions on tactical information supplied by officers in charge of specific combat areas (e.g., antiair warfare coordinator (AAWC), antisurface warfare coordinator (ASUWC), antisubmarine warfare coordinator (ASWC), and combat systems coordinator (CSC). These officers reside in the middle level of the hierarchy and receive input over separate internal nets from each other and from enlisted personnel at lower levels of the hierarchy. Occasionally, they also receive input from external radio links. Individuals are trained for positions they fill on the ship.

As the most visible and quantifiable element of team interaction, team communication patterns present a reasonable approach to studying team processes, such as crew coordination and group interaction (Foushee and Helmreich 1988). Lanzetta and Roby (1960) concluded in their report that performance is influenced by communication behaviors and the utilization of resources, at least as much as it is influenced by team knowledge of the problem. Foushee and Manos (1981) found that crews who communicated less performed less well and the type and quality of communication played an important role in performance. Specifically, there were fewer flight operation errors when more information was exchanged about flight status. Research describing how military terms affect the efficiency of communications and their impact on team training is reported in Achille et al. (1995) and Schulze et al. (1993). However, the functional roles of verbal communication in large Navy teams is not well understood. This report further explores team communication patterns by investigating the functional roles of verbal communication in large Navy teams.

Analysis of team communication in a naturalistic setting is challenging, and can be facilitated by partitioning the dialogue into smaller units that can be viewed on a continuum of increasing complexity. *Speech acts* (simple utterances) anchor the most basic level. One or more speech acts comprise a *speech turn,* which is normally bounded either by a pause to indicate the speaker has completed his message or by an interruption. A *transaction* refers to a sequence of speech turns (Kanki et al. 1989). Communication can be functionally analyzed by selecting speech turns as the

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unit of analysis and by using a coding scheme to describe the functional intent (Orasanu 1991) of each message. Speech turn analysis also permits an assessment of the communication patterns among team members.

Several analytical methods have been developed to code team communication at the speech turn level for air traffic controllers and aircrew communication (Foushee et al. 1986; Foushee and Manos 1981; Kanki and Foushee 1989; Orasanu 1990; Oser 1990; and Seamster et al. 1991). Because Navy teams have a deeper, more hierarchical structure than most aircrews, existing schemes that include such classifications as "command" and "response" are insufficient to analyze Navy teams. Navy team communication can be more correctly viewed as computer-supported cooperative work than can traditional cockpit communication, and some communication behaviors desirable in cockpits are not appropriate for Navy teams on ships.

The AEGIS weapon system is a state-of-the-art, computer-controlled system found on cruisers and destroyers. These AEGIS ships are the premiere front-line, surface combatants of the Navy. AEGIS team communications are less constrained by routine check lists and procedures and they are more oriented toward developing situational awareness. Therefore, a more detailed classification scheme was developed to incorporate new classifications (e.g., "status clarification," "statement of intent," and "prompts") to better reflect the nature of Navy team communication. The scheme was tailored for AEGIS communications based on differences between AEGIS teams and other smaller teams studied with the existing methods (Oser 1990 and Seamster et al. 1991).

Although military teams are required to explicitly issue commands that must be explicitly acknowledged, these requirements are not always consistently met in practice. Commands and acknowledgments constitute only a portion of the spectrum for team coordination, which also includes requests for information and observations. Several research teams have studied variables related to team coordination in military aircrew communication. Krumm and Farina (1962) found that better coordinated teams were more likely to volunteer information. Oser et al. (1989) found that cooperation and giving suggestions were important processes for team task accomplishment in combat information systems.

In nonmilitary teams, such as commercial aircrews, explicitly giving directions is more optional than it is in a military environment. The lack of a requirement to issue explicit commands often leads to implicit communication. Therefore, in a commercial environment, whether directions are explicitly or implicitly given may be a better indicator of team coordination than it is with military teams. Foushee and Manos (1981) found fewer errors in aircrews who acknowledged commands and made inquiries and observations more frequently. They saw a negative correlation between acknowledgments and errors of all types overall and that an increase in commands was related to a reduction in flying errors.

Training could improve team performance. Team communicators could be trained to "cooperate" more fully—offer each other more suggestions, make more inquiries, and issue more commands. This solution is not feasible, since it would increase the level of traffic on the command net. Operators wear headphones and monitor the internal command net with one ear, monitor the external radio net with the other ear, and frequently state their desire to have a "third ear" so they can gather all available information. Clearly, adding to their listening workload by increasing the quantity of words and messages is a less desirable alternative than improving the quality of the messages.

Without a description of the current use of communication, no balance can be struck between providing adequate relevant information and further overloading the communication network and team members. Quantitative data is needed to describe current communication behaviors and determine whether any specific types of verbal communication occur frequently enough to warrant recommending major design changes to future systems. Such changes might include computer interface mechanisms to reduce the need for or eliminate certain classes of communication. For example, with increasing capabilities of human computer interaction (HCI) technology, the possibility exists for reducing the load on the command network by incorporating speech recognition or by redirecting some of the workload onto the computer interface.

This study describes team communication, classifies it by the types of communication tasks, and identifies team members instrumental in accomplishing these tasks. This research was intended to investigate the following expectations:

1. Speech turn level communication analysis can be used to identify communication patterns and team member roles in the decision making process.

2. The spectrum of communication tasks and behaviors is not evenly distributed across speakers or functional intents.

3. Military teams are indoctrinated in the use of a chain of command and will show different patterns of communication than will commercial aircrews. In particular, increased experience will not reduce the necessity of issuing and acknowledging commands.

DATA COLLECTION AND ANALYSIS

Description of Collection

Team training exercises for a commissioning crew at the Combat Systems Engineering Development site in Moorestown, New Jersey, were observed and taped in the fall of 1991. The training sessions occurred daily for 2 weeks and included 13 1- to 2-hour simulated battle scenarios. These scenarios took place in a realistic mock-up of a CIC with simulated radar, sensor, and tactical information displayed on individual computer consoles and with team members using the internal and external communication nets to speak with one another. A prebriefing session gave background information about the tactical situation prior to each scenario, and a debrief session was used to discuss problems and errors as well as progress in team performance. Team members critiqued their own and other members' performance, but no formal evaluations were conducted. Although some of the team members knew each other, the observed crew had never worked together as a team. Digital tape recordings of verbal communications for all 13 training scenarios were collected (on a Sony DC10PRO digital tape recorder) by direct access to Net 15 (internal communication network among team members) and RT 4 (external communications within the battle group). Prebrief and debrief sessions were also recorded.

Each training scenario had a different geographic locale and emphasized different aspects of Navy warfare (e.g., antiair and antisubmarine). Two scenarios that focused on antiair warfare training were run twice during the 2-week period. These four scenarios were selected for transcription and form the basis of these communication analyses because they provided comparable situations, early and late in training.

Repeated scenarios contained similar sequences of events and activities but were not identical in length or content. Equivalent end points were identified by comparing the content of the two trials and terminating the longer scenario at the comparable event that ended the shorter trial. For example, the first run of one scenario was aborted before completion; so, rather than comparing the abbreviated first trial with the full-length second trial, an equivalent end point was established in the second trial. All analyses used scenarios adjusted to equivalent endpoints.

Classifications

Each speech turn was assigned at least 1 of 27 classifications that were generated to describe what is a very complex communication process. The classifications were analyzed at the speech turn level and each classification was counted individually. Two raters were trained in the assignment of speech classifications because some judgment was involved in determining the intent of speakers. Training included interpretation of the communications required before the speech turn could be classified and application of the individual classifications to a speech turn. Inter-rater reliability, computed for speech turn classifications by comparing rater judgments, was 83%. Disagreements were resolved by achieving consensus between the two raters.

The classification scheme consisted of 27 classifications that were divided into 8 major categories: CIC Activity, Situational Awareness, Planning, Acknowledgments, Communication Inefficiency, Overload, Disfluency, and Team Coordination. There was some overlap between the category definitions as indicated in the detailed definitions of the categories. In particular, Team Coordination overlaps three of the other categories and was created as a means of identifying information sharing for decision making based on Orasanu's (1990) definition of team coordination.

CIC Activity

These classifications comprise the basic and essential elements of command and control.

- *Command*—Any verbal order given that assigns responsibility for an action.
- *Reply*—Communication that supplies information beyond a simple acknowledgment or echo acknowledgment. It is usually in response to a specific inquiry.
- *Status Clarification*[1]—Any discussion to clarify the emerging tactical situation. An example is a request for factual information relating to past or present tasks. It is not a request for action.
- *Request for Information*—Any general inquiry that is not related to intended action or system status.
- *Permission Request*[2]—Any request up the chain of command to provoke an order.

Situational Awareness

This category contains classifications designed to foster a shared tactical view.

- *Situation-Related Observation*—Any statement to orient others to some aspect of task status; for example, stating newly available sensor data.
- *Status Clarification*[1]—Any discussion to clarify the emerging tactical situation. An example is a request for factual information relating to past or present tasks. It is not a request for action.

[1]Status clarification was placed in both the Situational Awareness and CIC Activity categories.

[2]Permission request was placed in both the Planning and CIC Activity categories.

- *Confirmation of Group Activity*—Communication that relates to group attainment of situational awareness, such as dropping a track from the scope.

Planning

Planning is characterized by discussion (statement or inquiry) of possible or intended courses of action in the completion of a mission.

- *Mission-Related Observation*—Any statement that provides unsolicited information to support the overall mission goals. This includes statement of goals, plans, and solution strategies.
- *Statement of Intent*—Any preview of information that will follow or an announcement of a speaker's intended action. It does not refer to previous actions.
- *Permission Request*[2]—Any request up the chain of command to provoke an order.
- *Suggestion*—Suggestion of possible action made up the chain of command. It can be phrased as a question.
- *Recommendation*—Any recommendation or suggestion where it is unknown[3] whether it was made up or down the chain of command.
- *Inquiry of Intent*—Any verbal request for information about another team member's intended action. This includes inquiries about both present and future actions but not inquiries about previous actions.

Acknowledgments

Acknowledgments give feedback to the speaker that the message was received.

- *Simple Acknowledgment*—Any verbal notation that a prior speech turn was heard. The speaker does not supply additional information nor does he correct or evaluate the prior speech turn. Examples are "copy" or "Air, aye."
- *Echo Acknowledgment*—Any verbal notation that a prior speech turn was heard where the accompanying statement is repeated back.

Communication Inefficiency

This category of classifications represents those that do not advance the state of the team's knowledge and do not contribute to the progression of the scenario. These classifications would not be needed if complete efficiency were possible.

- *Repeated Request for Information*—Any repeated request for specific information. It assumes that the original request was not responded to or that the initial response or question was not heard.
- *Prompt*—Any verbal notation to obtain the attention of one or more team member after an unsuccessful attempt to make contact. It is usually in the form of "recipient-speaker" followed by a delay until acknowledgment is received. It also includes other forms of attention-getting speech, such as "hot mike."
- *Say Again*—This classification is limited to the explicit verbal command of "say again." This is separated from the other repetitions because it is originated by the receiver, contains only those two words, and clearly indicates that the receiver did not hear or understand the speaker.

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[3]Speakers did not always identify themselves or their recipient. Hence, it was not always possible to determine whether the communication was up or down the chain of command.

- *Repetition*—Repeated communication that is not a question or a request. This includes responses given when someone is asked to repeat himself or when his original statement has not been acknowledged.

Overload

These classifications are related to network overload during periods of heavy network traffic or when the workload of one or more team members appears to have exceeded his capacity.

- *Afterthought*—Communication that is an addendum to or continuation of previous utterances. It may indicate overload or the anticipation of need.
- *Qualification*—Communication that expands a prior statement for clarification. For example, providing additional identification information about an entity to verify the subject of a discussion.

Afterthought and *qualification* are very closely related because they both refer to prior speech turns. They were used during periods of high communication workload and may function as a way of dispensing information over time.

- *Delay/Wait*—Any intentional delay in communicating, motivated by overload, uncertainty about existing information, or lack of information. It includes any deferral of response or deferral of information exchange, such as "stand by."
- *Correction*—Any verbal notation that corrects previous information. It also includes disagreements.
- *Silence On The Line*—Any explicit command that halts all other communication, usually "Silence on the line."

Disfluency

This category of classifications describes features of communication rather than functions of speech turns. It is an expansion of the definition of disfluency used by Kanki et al. (1989) to group incomplete thoughts, talking to oneself, and utterances. They tend to be more personally oriented than positionally oriented and may vary with the individual speaker. For example, a person with the habit of continually saying "uh" would have a high utterance count. *Extraneous utterances* and *format deviations* were used to describe features of speech turns used to perform other primary functions. *Uncodable* and *uninterpretable* speech turns are included in this set because the function of the speech turn could not be determined, and therefore, cannot be used in an analysis of speakers' functional intent. Although these two classifications are not strictly disfluencies, it was convenient for analytical purposes to include them in this category.

- *Extraneous Utterances*—Any nonword speech, such as "uh" and "um."
- *Format Deviations*—Any verbal notation that does not follow communication conventions, such as wordiness or conversational style, e.g., "Thank-you, sir."
- *Uncodable*—Any communication that either cannot be understood, is obscured by static interference, or cannot be coded according to this classification scheme.
- *Uninterpretable*—An observation of indeterminable relevance.

Team Coordination

All classifications, except those in the Disfluency category, were evaluated to determine if they were involved in team coordination. Classifications that describe activity among team members to facilitate the sharing of information for decision making, to provide feedback, to develop shared mental models, to foster situational awareness, or to develop mission plans were considered to be involved in team coordination (Orasanu 1990). Twelve of the 23 non-Disfluency classifications met these criteria and were placed in a summary category called Team Coordination. All classifications in the Situational Awareness and Planning categories fell into this category, as did two of the classifications (*afterthought* and *qualification*) from the Overload category.

Table 1 summarizes the distribution of the classifications among the categories.

Table 1 — Distribution of the 27 Classifications Among the 8 Classification Categories

CIC Activity	Situational Awareness	Planning	Acknowledgments
Command	Situation-Related Observations	Mission-Related Observation	Simple
Reply	Status Clarification	Statement of Intent	Echo
Status Clarification	Confirmation of Group Activity	Permission Requests	
Permission Request		Suggestion	
Request for Information		Recommendation	
		Inquiry of Intent	
Communication Inefficiency	**Overload**	**Disfluencies**	**Team Coordination**
Repeated Request for Information	Afterthought	Extraneous Utterances	Situational Awareness
Prompt	Qualification	Format Deviations	Planning
Say Again	Delay/Wait	Uncodable	Afterthought
Repetition	Correction	Uninterpretable	Qualification
	Silence on the Line		

Classifications for All Speech Turns and for Major Speakers

The original scenarios were analyzed to determine frequencies for each classification and these were totaled within the eight defined categories. Nonfunctional classifications (*uncodable*, *uninterpretable, format deviation*, and *extraneous utterances*) were identified and tallied. They were excluded from the data set upon which the rest of the analyses were performed.

Frequency comparisons for all speakers were made for classification categories between early and late training. This was done to examine patterns of functional activity in team communications.

Separate analyses were conducted to compare frequencies between early and late training for individual classifications that have been shown (Foushee and Manos 1981) to impact team performance. These include *command, reply, acknowledgment, statement of intent, inquiry of intent, request for information, repeated request for information*, and *status clarification*. Disfluencies and *observations* were also chosen for analysis based on their high frequency of occurrence.

Speech turns were analyzed to identify the major speakers. Analyses were conducted on each category to determine whether the classification frequencies of the major speakers significantly differed from expectations based on their relative level of communication activity. Selected analyses were conducted to determine changing communication patterns for individuals who exhibited large differences from early to late training.

Multiply Classified Speech Turns

In some cases, multiple classifications were assigned to a single speech turn and these were analyzed separately. Multiple coding occurred for two reasons. Some of the classifications are general in nature and not descriptive of functional intent, such as *format deviations* ("uh, uhm,"), which could be applied to any speech turn. In this case, a speech turn might have a single purpose. For example, a simple command might have multiple classifications if it included nonfunctional speech such as a *format deviation*. In other cases, a single speech turn could accomplish dual purposes because it consisted of multiple phrases with separate communication intent. For example, a team member might use a speech turn to respond to a question and follow up with an additional inquiry of his own. In such instances, a speech turn would have two different classifications. An analysis was performed to look for relationships between communication functions to determine whether certain classifications tended to coexist.

To analyze the data files for multiply classified speech terms, the files were modified to eliminate all speech turns that were described by a single classification. Speech turns that were coded as *simple* or *echo acknowledgments* or classifications that were not descriptive of communication functional intent (e.g., *format deviations, extraneous utterances, uninterpretable*, or *uncodable*) were eliminated from the data set to avoid including speech turns with a single function simply because more than one classification was assigned to them. Any remaining speech turns coded with a single classification were eliminated. The resulting data set containing dual-coded and triple-coded speech turns was sorted by classifications. Each of the ten triple-coded speech turns could be viewed as three different dual combinations. When this was done, there were 256 possible combinations of dual classifications. Multiply classified speech turns were then identified and counted. Any combination of two classifications with a frequency of six or less was discarded.

RESULTS

The database generated from the 4 scenarios contained 1670 speech turns and 2283 classifications. Disfluency classifications comprised 19.2% of the speech classifications. The *uncodable* and *uninterpretable* classifications, taken together, comprised 3.3% of the total classifications and 4.6% of the total speech turns. The remaining two descriptive classifications (*format deviation* and *extraneous utterances*) comprised 15.9% of the total. When the Disfluency classifications were eliminated, 1844 classifications remained for analysis. Classification frequencies are shown in Appendix A, and these frequencies are broken down by scenario in Appendix B.

Comparison of Functional Classification Categories for All Speakers and Major Speakers

Table 2 summarizes the percentage of classifications used in the remaining seven functional categories for all speakers.

Table 2 — Distribution of Classifications by the Seven Functional Classification Categories Shown as a Percentage of all Classifications[4]

Classification Category	Percentage of Total Classifications
Team Coordination	42.7
CIC Activity	29.4
Situational Awareness	24.0
Planning	14.8
Acknowledgments	26.4
Communication Inefficiency	6.8
Overload	5.2

Officers at the top and middle levels of the command hierarchy (TAO, Air, Surface, Subs, and Combat positions, hereafter referred to as the "Major Speakers") initiated 74% of the speech turns and 73% of the classifications.

Of the 1844 classifications, 1422 were attributed to speech turns spoken by the major speakers. However, their communication activity was not evenly distributed across the functional classification categories. Table 3 shows that when the actual number of classifications attributed to the major speakers in each of the seven categories (CIC Activity, Situational Awareness, Planning, Acknowledgments, Communication Inefficiency, Overload, and Team Coordination) was compared as revealed by a χ^2 analysis, to its expected value (based on overall communication activity), the number of classifications in the Acknowledgments and Team Coordination categories for the major speakers was significantly higher than expected, while Table 3 shows the number in Situational Awareness was lower.

[4]Percentages in the table exceed 100% because Team Coordination is a summary category and some categories share a classification.

Table 3 — Percentage of Total Classifications for Each Functional Category by All Speakers That are Attributed to Five Major Speakers

Category	Actual Percentage	χ^2
Team Coordination	70.7	31.9***
CIC Activity	79.4	2.1
Situational Awareness	63.0	65.0***
Planning	80.5	1.9
Acknowledgments	85.4	25.0***
Communication Inefficiency	79.4	0.3
Overload	75.8	0.04

***$p < 0.001$

Patterns of Functional Activity by Major Speakers

When looking for patterns of functional activity by individuals, it is useful to compare both frequency by functional category and the percentages of a speaker's total work calculated from those frequencies. There is wide variability between team members when their total communication activity level is compared. Therefore, the functional activities of team members were computed as a percentage of their communication activity to determine how their effort was distributed.

Team Coordination

Team coordination is presented separately because it is the most prominent activity for team members at all levels. As a summary category that includes classifications from Situational Awareness, Planning, and Overload, all the major speakers are involved in Team Coordination (Fig. 1(a)). Only 17.8% of the TAO's effort is in Team Coordination, while the remaining major speakers average around 50% (Fig. 1(b)). Team members in the lower tiers of the hierarchy contribute more speech turns (231) classified as Team Coordination than any one individual (Fig. 1(a)), which is approximately 29.35% of all Team Coordination classifications. With the exception of the TAO's lower activity, team coordination occupies approximately half the communication effort of the entire team. Only acknowledgments approach this level of prominence and their most extensive use is restricted to the TAO.

The main functional activities of communication are summarized by speaker in Fig. 2. Figure 3 shows the contributions of speakers to individual functional categories. The results for each functional category are discussed in turn by importance.

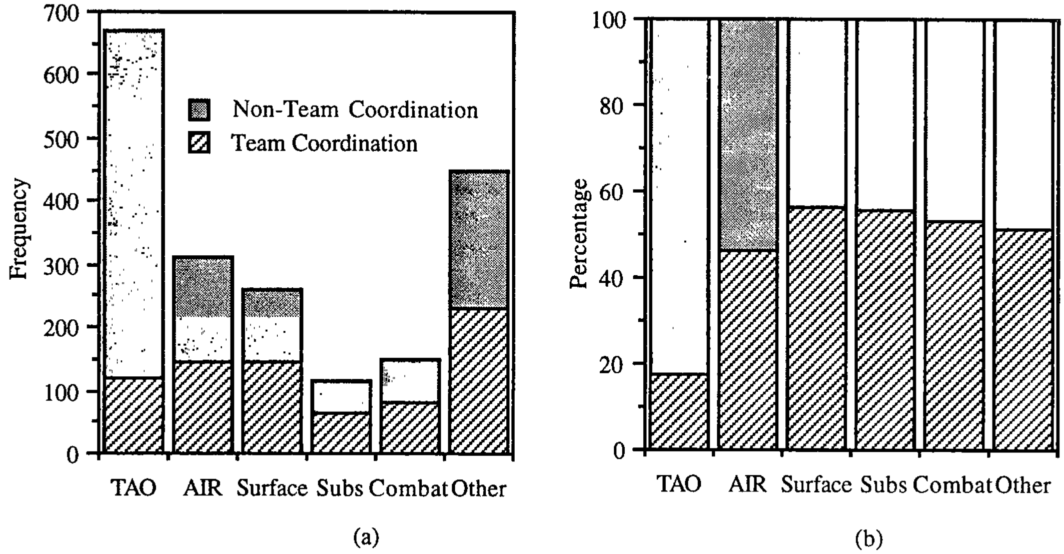


Fig. 1 — (a) Frequency of Team Coordination vs Non-Team Coordination classifications by speaker.
(b) Percentage of Team Coordination classifications for each speaker.

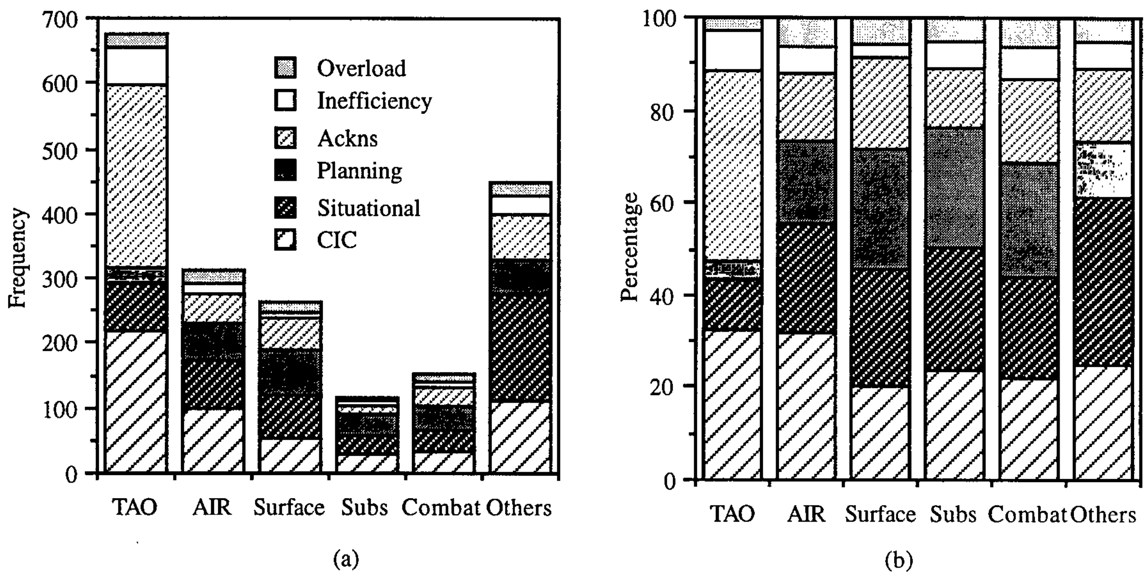
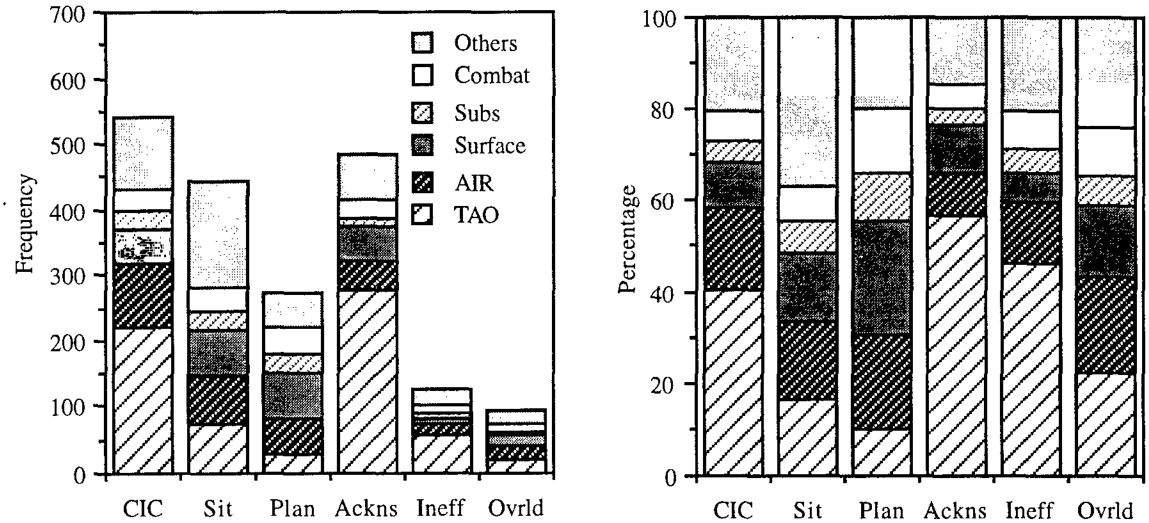


Fig. 2 — (a) The frequency distribution of the six functional classification categories by speaker.
(b) The percentage of each speaker's classifications attributed to each category.



(a) (b)

Fig. 3 — (a) The frequency distribution of the six classification categories for all speakers. (b) The percentage of each functional classification category attributed to each speaker.

CIC Activity

More speech turns (543 classifications) were coded as CIC Activity than for any other category (Fig. 3(a)). The most prominent participants were TAO, Air, and lower level team members taken together (hereafter referred to as "Others"). The TAO and Air account for 73.5% of the CIC Activity resulting from the major speakers and 58.4% of all CIC Activity (Fig. 3(a)). TAO's frequency was more than double that of Air (Fig. 2(a)), but when the percentages of their individual contributions were compared, they each devoted approximately 32% of their effort to CIC Activity (Fig. 2(b)). The TAO's CIC Activity frequencies and the sum of all those of the middle level officers were approximately equal.

Situational Awareness

The Situational Awareness category accounted for 443 of the classifications. Lower level team members were the most active participants and were responsible for 37% of the classifications in this category (Fig. 3(b)). The number of classifications in the Situational Awareness category for the major speakers was significantly less than expected (based on their total communication activity) (Table 4). TAO, Air, and Surface contributed 77.1% of the major speakers' efforts in roughly equal frequencies and 48.5% of all Situational Awareness activity (Fig. 3(b)). However, when taken as a percentage of his individual communication, Fig. 2(b) shows that the TAO devoted only half as much to this category as either Air or Surface.

Table 4 — Summary Statistics Comparing Frequencies by Classification Categories Between Early and Late Training

Classification Category	Early	Late	χ^2
Team Coordination	416	371	2.3
CIC Activity	306	237	9.5*
Situational Awareness	229	258	3.6
Planning	145	128	0.6
Acknowledgments	213	273	12.5***
Communication Inefficiency	49	51	0.1
Overload	48	47	0.002

*$p < 0.05$
***$p < 0.001$

Planning

Only 14.8% of the classifications can be attributed to planning. Air, Surface, and team members at the lower level of the hierarchy are the most active participants, and as Fig. 3(b) shows, this distribution is relatively even. Of the 273 classifications in the Planning category, 124 were attributed to Air and Surface speech turns, which accounted for 56.6% of the planning done by the major speakers and 45.6% of all planning. If planning behavior is evenly distributed across the major speakers, the TAO would be expected to initiate approximately 20% of the planning speech turns. However, the TAO was only responsible for 9.9% of all planning and only 12.3% of the planning done by the major speakers.

Acknowledgments

The second most active category was Acknowledgments (486 classifications). TAO was the most dominant player, producing 57% (Fig. 3(b)) of all acknowledgments, 66.7% of acknowledgments by the major speakers, and 41% of his own communication.

Communication Inefficiency

Communication inefficiencies comprised 6.8% (126) of the classifications. Even though almost half (46%) of the communication inefficiencies can be attributed to the TAO (see Fig. 3(b)), it is comparable to the percentages of the other major speakers when taken as a percentage (see Fig. 2(b)).

Overload

Overload was the least active category, attributing to only 5.15% (95) of the classifications. The busiest speakers (TAO, Air, and Surface) have a larger proportion of the Overload, and Fig. 3(b) shows it is relatively evenly distributed among them. However, when viewed as a percentage of his individual speech, the TAO's percentage (3.1%) was about half of the average (5.8%) of all the other speakers, even though Fig. 2(a) illustrates he was the most active speaker.

Comparison of Functional Classification Categories for Early-to-Late Training

Table 4 compares frequencies for each classification category between early and late training. The table shows a significant increase in Acknowledgments and a significant decrease in CIC Activity between early and late training. A conspicuous but not statistically significant increasing trend for Situational Awareness is also evident. There was no significant change over training in the remaining functional categories.

Selected Classification Analysis

Table 5 lists individual classifications that showed a significant change over training and their frequencies. *Statements of intent*, *inquiry of intent*, and *status clarifications* remained relatively constant over training. Although Disfluencies decreased and *situation-related* and *mission-related observations* increased, the changes were not significant. There was a strong but not significant increase in *commands* issued by the major speakers.

Table 5 — Summary Statistics for Selected Classification Analyses

Classification Codes	Early	Late	χ^2
Reply	76	43	7.3**
Acknowledgments	176	239	17.8***
Request and Repeated Requests for Information[5]	50	28	4.7*
TAO Request for Information	20	7	4.7*

*$p \leq 0.05$
**$p \leq 0.01$
***$p \leq 0.001$

Multiply Classified Speech Turns

Each speech turn was assigned at least one classification in the scheme, with 29.3% being assigned more than one classification. There were 236 (14.1%) speech turns with dual or triple-coded classifications after Disfluency classifications were eliminated. Pairs that occurred together at least

[5]The frequencies for classifications *request for information* and *repeated requests for information* were counted together for this analysis.

seven times accounted for 71.2% of the multiply coded speech turns. In no cases were two classifications assigned together more frequently than would be expected to occur by chance.

The most frequent occurrence of dual coding existed with *mission-related observation* and *confirmation of group activity,* which were used together in 13 instances for 2.8% of all speech turns. *Confirmation of group activity* occurred concurrently with *commands* (9 instances) and *mission-related observations* were coded as *replies* 10 times. There was no overlap between the classifications in the Communication Inefficiency category and any other category.

DISCUSSION

Communication patterns evident in this analysis provide some insight into team members' roles in the Command and Control process and suggest differences between the communication processes of large Navy teams and aircrews. Participation of team members in the functional activities accomplished by communication can be described as a result of speech-turn-level analysis.

Aircrew communication analysis literature suggests training should result in fewer commands being issued with increased experience. Military environments demand continued use of explicit commands to assign responsibility, and this requirement may have influenced command frequency. In this data set, commands increased with training, while all other CIC activities decreased. These other CIC components serve a supporting function to provide background information that can be used in Command and Control. The reduction in noncommand CIC Activity, after training, implies that information is being provided through observations or by some other means and the primary decision maker is getting more of the information he needs to command the team.

Naval personnel are trained to explicitly acknowledge all verbal commands. Since the TAO was the most active participant, it is not surprising he spent more time than anyone else acknowledging other speakers. Beyond the sheer number of speech turns he produced, his high frequency of acknowledgments suggests his role is a focus for decision making. As the recipient of information from all team members, he is best able to consider decisions in a rich context.

Several interrelated changes in the frequency of selected classifications over training provide evidence that information flow has improved throughout the team. An increase in acknowledgments suggests team members have streamlined the content of their speech turns to the extent that many do not require elaboration. The decrease in requests for information both from the TAO and from the team at large is probably directly related to the decrease in replies. More information is being supplied without being requested, as evidenced by the increased number of observations. Taken in combination, these changes suggest team coordination has improved and that team members are probably receiving more of the information they need to better develop situational awareness.

It is interesting to note that the number of classifications in the Situational Awareness category attributed to the major speakers was significantly less than expected. While the lower-level team members were the most active in this category, this may be dictated by their role as gatherers of sensor data. Their activity shows up in communication because they are responsible for relaying new information to team members above them in the hierarchy. The effort to maintain situational awareness seems to be distributed across the entire team and probably is part of each team member's general responsibility, unlike planning activity, which was concentrated in the middle tiers. While major speakers must maintain situational awareness to function effectively in the command environment, they are probably doing so nonverbally.

In nonmilitary contexts, a close analog to development of situational awareness is information gathering. Orasanu (1990) found more effective captains gather more information and thus are better prepared to deal with arising crises. In this study, there was a strong, increasing trend in situational awareness activity and fewer requests for information from the TAO. This suggests more information is being "offered" to him and supports the belief that aircrew and Navy team processes are different. In Navy teams, the TAO may simply be too busy to request information and depends on his team to provide it.

Orasanu (1990) also found differences in the distribution of the types of communication between effective captains and noneffective captains, with those more effective captains focusing on stating their intentions and making contingency plans. Schulze et al. (1993) theorized raw information is filtered by team members as it passes up the chain of command to the decision maker(s). Most planning was done by middle-level officers, with approximately half the planning being done by Air and Surface. The TAO's minimal participation in planning suggests that the primary decision maker's role in planning is to approve or disapprove plans presented up the command hierarchy. This suggestion is compatible with his status as the most active participant in CIC Activity, with the theory that information is processed for use at higher levels in the command hierarchy, and with the belief that Navy team processes differ from those of commercial aircrews.

The small percentage of Communication Inefficiency suggests that the team is relatively well-trained to deal with the heavy communication load on the network. The small percentage of communication attributed to Overload implies either the team is not as overloaded as anecdotal evidence suggests or that they are very effective in dealing with it.

When the major speakers are examined as a category, gross patterns of behavior can be identified. For example, a higher-than-expected number of classifications from the Acknowledgments and the Team Coordination categories suggests the major speakers are providing feedback and acting as the "glue" holding together those team members above and below them in the hierarchy. Indeed, the prominence of team coordination data evident here indicates that team coordination is an important function of communication and an integral part of team command and control.

Scenario focus is likely to affect an individual team member's participation and must also be considered while examining these patterns. Because these scenarios focused on antiair warfare, it is not surprising that Air was a highly active participant in Command and Control communication and that Subs and Surface were not as active participants in Situational Awareness or Planning. Of course, the TAO is ultimately responsible for running the CIC (barring the Captain, who rarely intervened), so it is not surprising that his participation approximately equaled the total participation of the middle level officers.

Recommendations for Further Research

The results suggest two areas where communication efficiency on the command net might be reduced through automated assistance and/or through training. Previous studies (Schulze et al. 1993) have shown that there is usually a heavy load on the communication network. Further, operators' hands and eyes are busy with their computer systems. Care must be taken to ensure that any changes to the interface do not confound these problems.

Although the performance of many speech recognition systems leaves much to be desired, devices that reliably recognize a few specific utterances can have profound effects. Speech recognition research (Oviatt 1994; Cowley and Jones 1993; Franzke et al. 1993) has shown that the number of disfluencies remains low when automated recognition systems are used for short speech turns. Users of these systems find them easier to use and more time effective than traditional interfaces.

The majority of speech turns were preceded by a short phrase where the speaker named the intended recipient and then identified himself (e.g., "Air, TAO. What is the ...?"). This convention is intended to alert the recipient that he is being spoken to and to save the recipient from having to determine who is speaking. Schulze et al. (1993) found that even though speakers explicitly identify themselves only 62.2% and their recipients 57.4% of the time, the explicit identification of speakers and recipients accounts for an important segment of communication time on the network.

Research is needed to investigate whether speech recognition technology could interpret speaker/recipient identity and present it on specialized displays. These displays would indicate the identity of current speaker and receivers to the entire team. This would provide redundant feedback for some team members; it would also provide a means for others to orient themselves to the situation. We suspect that situational awareness is partially built by listening to other team members communicate on the net. Each listener considers the source of information, both when they are participants in a conversation and when they are merely listeners. Therefore, the impact of removing speaker and receiver identification information and the concomitant context from the team, at large, must be carefully assessed.

Acknowledgments occur frequently enough that if they were transferred to the interface, nearly one quarter of all speech turns would be eliminated, thereby reducing the network load. It may be possible to automate this process and incorporate acknowledgments into the computer display. Since the TAO was responsible for more than half of the Acknowledgments, his communication load would be substantially reduced by providing some automated assistance. Since the TAO is at the top of the hierarchical team and the primary decision maker, any relief provided him would benefit the entire team.

In addition to possible automated assistance, training could also have an impact on the communication-network load. Training could make speakers aware of unconscious utterances (*extraneous utterances*) and unnecessary communication (*format deviations*), such as "thank you." Although these utterances would be a minor issue for a single individual, when the entire team exhibits this behavior, it becomes a more significant issue. If speakers could eliminate these utterances, as many as 15% of the speech turns could be shortened, thereby reducing the load on the communication network.

Research is needed to determine whether any functions accomplished in verbal communications can be effectively transferred to the computer interface or to a supplementary, automated speech recognition system. The mechanisms mentioned above are only a subset of those possible. It is unknown which techniques would be most effective and what effects they might have on team performance. For example, shifting speaker identification from verbal communication to a manual activity may not be feasible because of the current heavy manual requirements on the operator.

SUMMARY

Detailed analysis has provided objective descriptive data for large team communication in a naturalistic setting that is often considered too subjective and difficult to quantify (Seamster et al. 1992). The specification of communication strategies is an integral component of the effort to delineate effective behavior and to have a positive influence on training. Some team members may spontaneously adopt effective strategies for communication, but most will require training.

Because performance data was not available for this corpus, it was not possible to correlate classification patterns with operational errors and other performance measures as has been done in similar studies (Foushee and Manos 1981). Therefore, additional work is needed to establish criteria to determine the predictability of classification coding and whether changes observed in communication patterns over training are related to the development of communication conventions (Kanki et al. 1989) that enhance team coordination and team performance.

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Appendix A

CLASSIFICATION FREQUENCY TOTALS